U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject:	INFORMATION: Equivalent Level of Safety Finding (ELOS) for Bombardier Aerospace model BD-100-1A10 TC2500NY-T	Date:	May 20, 2003
		Reg Ref	All part 25 sections dealing with stall speeds and related functions, except structural
From:	Manager, Transport Airplane Directorate, Airplane & Flight Crew Interface, ANM-111	Reply to Attn. of:	Bruce Valentine ANE-172
To:	Manager, New York ACO	ELOS Memo #	TC2500NY-T-F-1

The purpose of this memorandum is to inform the certificate management certification office of an evaluation made by the Transport Airplane Directorate on the establishment of an equivalent level of safety finding for the Bombardier Aerospace model BD-100-1A10 Challenger 300.

Background

An equivalent safety finding for the use of 1-g stall speeds, instead of the minimum speeds obtained in the stalling maneuver, as the basis for showing compliance with certain FAR 25 performance, was established for several past type certification projects. Pilot objectivity on stall identification has become a key factor in decisions on flying technique, especially where deterrent buffet or excessively low load factors are developed during stalls to $V_{S\ MIN}$. To avoid these problems, and to become consistent with recent certification practice, the application of 1-g stall speed criteria is being expanded to include most areas of the transport-related regulations that use stall speed as a factor.

The 1-g stall requirements were derived to provide a more realistic and consistent basis for the definition of stall speed as the minimum speed at which wing lift alone can support the weight of the airplane in level flight. Service history has not indicated a safety related deficiency in existing operating speeds that typically have their minimum allowable values defined as a multiple of the $V_{S\ MIN}$ stall speed. Consequently, the 1-g stall Issue Papers have applied reduced operating speed factors for determining the minimum operating speeds in order to compensate for the 1-g stall speeds being higher than $V_{S\ MIN}$ speeds. The net result was little or no change in operating speeds for airplanes with aerodynamic stall, thus leading to a finding of equivalent safety.

Applicable Regulations

§§ 1.1, 1.2, 25.103, 25.107, 25.111, 25.119, 25.121, 25.125, 25.143, 25.145, 25.147, 25.149, 25.161, 25.175, 25.177, 25.181, 25.201, 25.207, 25.233, 25.237, 25.735, 25.773, 25.1001, 25.1323, 25.1325

Regulation(s) Requiring an ELOS

Several FAR's for the use of 1-g Stall Speed (nonstructural items)

Description of compensating design features or alternative standards which allow the granting of the ELOS (including design changes, limitations, or equipment needed for equivalency)

Bombardier will certify a stall identification system in order to use the 1-g stall criteria. The system will be designed so that it performs its intended function reliably and safely.

With respect to reliability, it will be designed to function as required when needed to protect the airplane from unacceptable stall characteristics. Safety aspects of the design will ensure that there is lack of unwanted operation, no dynamic excursion to unsafe angles of attack, and no unsafe operation during takeoff and landing when ground clearance is at a minimum

The reference stall speed used to determine the minimum operating speeds will not be less than the greater of 2 knots or 2 percent above the speed at which the device activates. Because of the requirement for a 2-knot or 2 percent margin between the reference stall speed and the device activation speed, there will be a minimum 5-knot or 5 percent margin between the stall warning speed and the device activation speed. (A 3-knot or 3 percent margin is required between the reference stall speed and the stall warning speed.)

The stall warning margin itself must be sufficient to provide more aggressive maneuvering capability (e.g., collision avoidance) without the stall identification system activating. Section § 25.207(a) requires the stall warning margin to be capable of preventing the airplane from reaching the pusher activation angle of attack in slow-down turns at 1.5g, with entry rates greater than 2 knots per second, when pilot action to recover is not initiated until one second after the onset of stall warning.

In addressing reliability and safety concerns, Bombardier Inc. will consider the combined effects of the following variables to determine the critical fleet wide configuration for stall testing:

1. High lift device and control surface rigging - at the limits of their respective tolerance bands that is most detrimental to the production of lift;

2. Airframe build tolerances - the impact of wing angle of incidence variation relative to stall identification system vane angle;

3. Stall identification system tolerances - activation vane angles should be at the low end of the tolerance band for stall speed testing, and at the high end for stall characteristics testing; and

4. Wing leading edge condition - the effect of wing leading edge contamination (e.g., insects) on stall speeds should be determined and accounted for if significant. The critical height and density of the contaminant should be substantiated by Bombardier Inc. This testing may be accomplished using an artificial contaminant.

A maximum deviation in stall speed of ±1 knot, from that defined in the nominal configuration, is considered acceptable for the combined effects of Items 1 through 3, above. The deviation in stall speed due to stall identification system tolerances (Item 3), alone, should not exceed ±0.5 knots (the stall identification system consists of everything from the angle of attack sensing device to the connection of the force application actuator to the longitudinal control system).

It must be verified that threshold tolerances and system design features (e.g., filtering, phase advancing) will not result in an unsafe diminishing of the margin between stall warning and pusher activation, or pusher activation and some dangerous airplane characteristic. Investigations will include the demonstration of maneuver margins, dynamic stall entries, the effects of atmospheric turbulence, and operation in windshear environments where the airplane will be flown at, or very near, stall warning. These flying conditions should not result in unwanted activation of the stall identification system or aerodynamic stall prior to, or close to, activation of the stall warning system. This verification may be provided by a combination of analysis, simulation, and flight test.

The following constitutes the FAA's equivalent interpretations of the referenced Federal Aviation Regulations that will provide an equivalent level of safety for the Bombardier Inc. BD-100-1A10:

CFR 14 Reference	Equivalent Interpretations for Bombardier Inc. BD-100-1A10
Part 1 (Definitions and abbreviations)	
1.1	Add the following new definitions: "*Final takeoff speed* means the speed of the airplane that exists at the end of the takeoff path in the en route configuration with one engine inoperative." "*Reference landing speed* means the speed of the airplane, in a specified landing configuration, at the point where it descends through the landing screen height in the determination of the landing distance for manual landings."
1.2	Add the following new abbreviations: "V_{FTO} means final takeoff speed."

"V_{REF} means reference landing speed."

"V_{SR} means reference stall speed."

"V_{SR0} means reference stall speed in the landing configuration."

"V_{SR1} means reference stall speed in a specific configuration."

"V_{SW} means speed at which onset of natural or artificial stall warning occurs."

Part 25 (Airworthiness Standards: Transport Category Airplanes)

25.103(a)

Change to read: "The reference stall speed, V_{SR}, is a calibrated airspeed defined by the applicant. V_{SR} may not be less than a 1-g stall speed. V_{SR} is expressed as:

$$V_{SR} \geq \frac{V_{CL_{MAX}}}{\sqrt{n_{zw}}}$$

where

$V_{CL_{MAX}}$ = Calibrated airspeed obtained when the load factor-corrected lift coefficient ($\frac{n_{zw}W}{qS}$) is first a maximum during the maneuver prescribed in paragraph (c) of this section. In addition, when the maneuver is limited by a device that abruptly pushes the nose down at a selected angle of attack (e.g., a stick pusher), $V_{CL_{MAX}}$ may not be less than the speed existing at the instant the device operates;

n_{ZW} = Load factor normal to the flight path at $V_{CL_{MAX}}$

W = Airplane gross weight;

S = Aerodynamic reference wing area; and

q = Dynamic pressure that $V_{CL_{MAX}}$ is determined with"

NOTE: Unless AOA protection system (stall warning and stall identification) production tolerances are acceptably small, so as to produce insignificant changes in performance

determinations, the flight test settings for stall warning and stall identification should be set at the low AOA tolerance limit; high AOA tolerance limits should be used for characteristics evaluations.

25.103(a)(1)	Change to read: "Engines idling, or, if that resultant thrust causes an appreciable decrease in stall speed, not more than zero thrust at the stall speed;"
25.103(a)(2)	Change to read: "Propeller pitch controls (if applicable) in the takeoff position;"
25.103(a)(3)	Insert a new paragraph that reads: "The airplane in other respects (such as flaps and landing gear) in the condition existing in the test or performance standard in which V_{SR} is being used;"
25.103(a)(4)	Renumbering of the old § 25.103(a)(3) and change "V_S" to "V_{SR}."
25.103(a)(5)	Change to read: "The center of gravity position that results in the highest value of reference stall speed; and"
25.103(a)(6)	Insert a new paragraph that reads: "The airplane trimmed for straight flight at a speed selected by the applicant, but not less than 1.13 V_{SR} and not greater than 1.30 V_{SR}."
25.103(b)	Change to read: "Starting from the stabilized trim condition, apply elevator control to decelerate the airplane so that the speed reduction does not exceed one knot per second."
25.103(b)(1)	Remove this paragraph.
25.103(b)(2)	Remove this paragraph.
25.103(c)	Insert a new paragraph that reads: "In addition to the requirements of paragraph (a) of this section, when a device that abruptly pushes the nose down at a selected angle of attack (e.g., a stick pusher) is installed, the reference stall speed, V_{SR}, may not be less than 2 knots or 2 percent, whichever is greater, above the speed at which the device operates."
25.107(b)(1)	Change "1.2 V_S" to "1.13 V_{SR}."

25.107(b)(2)	Change "1.15 V_S" to "1.08 V_{SR}."
25.107(c)(3)	Insert a new paragraph that reads: "A speed that provides the maneuvering capability specified in § 25.143(g)."
25.107(g)	Insert a new paragraph that reads: "V_{FTO}, in terms of calibrated airspeed, must be selected by the applicant to provide at least the gradient of climb required by § 25.121(c), but may not be less than-- (1) 1.18 V_{SR}; and (2) A speed that provides the maneuvering capability specified in § 25.143(g)."
25.111(a)	Replace "a speed is reached at which compliance with § 25.121(c) is shown" with "V_{FTO} is reached."
25.119(b)	Change to read: "A climb speed of not more than V_{REF}."
25.121(c)	Change to read: "...for four engine airplanes, at V_{FTO} and with –"
25.121(d)	Change to read: "In a configuration corresponding to the normal all-engines-operating procedure in which V_{SR} for this configuration does not exceed 110 percent of the V_{SR} for the related all-engines-operating landing configuration, the steady gradient of climb may not be less than 2.1 percent for two-engine airplanes, 2.4 percent for three-engine airplanes, and 2.7 percent for four-engine airplanes, with –"
25.121(d)(3)	Change to read: "...but not more than 1.4 V_{SR}; and"
25.121(d)(4)	Add new paragraph as follows: "Landing gear retracted."
25.125(a)(2)	Change to read: "A stabilized approach, with a calibrated airspeed of not less than V_{REF}, must be maintained down to the 50 foot height. V_{REF} may not be less than—

(i) 1.23 V_{SR0}; and

(ii) V_{MCL} established under § 25.149(f); and

(iii) A speed that provides the maneuvering capability specified in § 25.143(g)."

25.143(g) Insert a new paragraph that reads: "The maneuvering capabilities in a constant speed coordinated turn at forward center of gravity, as specified in the following table, must be free of stall warning or other characteristics that might interfere with normal maneuvering:

CONFIG-URATION	SPEED	MANEUVERING BANK ANGLE IN A COORDINATED TURN	THRUST/POWER SETTING
TAKEOFF	V_2	30°	ASYMMETRIC WAT-LIMITED.[1]
TAKEOFF	V_2 + XX [2]	40°	ALL-ENGINES-OPERATING CLIMB.[3]
ENROUTE	V_{FTO}	40°	ASYMMETRIC WAT-LIMITED.[1]
LANDING	V_{REF}	40°	SYMMETRIC FOR -3° FLIGHT PATH ANGLE

(1) A combination of weight, altitude and temperature (WAT) such that the thrust or power setting produces the minimum climb gradient specified in § 25.121 for the flight condition.

(2) Airspeed approved for all-engines-operating initial climb.

(3) That thrust or power setting which, in the event of failure of the critical engine and without any crew action to adjust the thrust or power of the remaining engines, would result in the thrust or power specified for the takeoff condition at V_2, or any lesser thrust or power setting that is used for all-engines-operating initial climb procedures."

25.145(a), (a)(1) Change to read: "It must be possible, at any point between the trim speed prescribed in § 25.103(a)(6) and stall identification (as defined in § 25.201(d)), to

	pitch the nose downward so that the acceleration to this selected trim speed is prompt with-
	(1) The airplane trimmed at the speed prescribed in § 25.103(a)(6);"
25.145(b)(1) - (4)	Change "1.4 V_{S1}" to "1.3 V_{SR1}."
25.145(b)(1)	Change "40 percent" to "30 percent."
	Change "stalling speed" to "reference stall speed."
25.145(b)(6)	Change "1.4 V_{S1}" to "1.3 V_{SR1}."
	Change "1.1 V_{S1}" to "V_{SW}."
	Change "1.7 V_{S1}" to "1.6 V_{SR1}."
25.145(c)	Change "1.1 V_{S1}" to "1.08 V_{SR1}."
	Change "1.2 V_{S1}" to "1.13 V_{SR1}."
25.147(a), (a)(2), (c), (d)	Change "1.4 V_{S1}" to "1.3 V_{SR1}."
25.149(c)	Change "1.2 V_S" to "1.13 V_{SR}."
25.161(b), (c)(1), (c)(2), (c)(3), (d)	Change "1.4 V_{S1}" to "1.3 V_{SR1}."
25.161(e)(3)	Change "0.013 V_{S0}^2" to "0.013V_{SR0}^2."
25.175(a)(2), (b)(1), (b)(2), (b)(3), (c)(4)	Change "1.4 V_{S1}" to "1.3 V_{SR1}."
25.175(b)(2)(ii)	Change "V_{MO} + 1.4 V_{S1}/2" to "(V_{MO} + 1.3 V_{SR1})/2."
25.175(c)	Change speed range to: "...at speeds between V_{SW} and 1.7 V_{SR1}."
25.175(d)	Change speed range to: "...at speeds between V_{SW} and 1.7 V_{SR0}."
25.175(d)(5)	Change "1.4 V_{S0}" to "1.3 V_{SR0}."
25.177(c)	Change "1.2 V_{S1}" to "1.13 V_{SR1}."

25.181(a), (b)	Change "1.2 V_S" to "1.13 V_{SR}."
25.201(a)(2)	Change "1.6 V_{S1}" to "1.5 V_{SR1}" and "V_{S1}" to "V_{SR1}." Change "stalling speed" to "reference stall speed."
25.207(c)	Change to read: "When the speed is reduced at rates not exceeding one knot per second, in straight flight with engines idling and at the center-of-gravity position specified in § 25.103 (a)(5), stall warning must begin, in each normal configuration, at a speed, V_{SW}, exceeding the reference stall speed by not less than three knots or three percent, whichever is greater. Once initiated, stall warning must continue until the angle of attack is reduced to approximately that at which the stall warning began."
25.207(d)	Insert a new paragraph that reads: "In slow-down turns at 1.5g load factor normal to the flight path and airspeed deceleration rates greater than two knots per second, with the flaps and landing gear in any normal position, the stall warning margin must be sufficient to allow the pilot to prevent stalling (as defined in § 25.201(d)) when recovery is initiated not less than one second after the onset of stall warning."
25.207(e)	Insert a new paragraph that reads: "Stall warning must also be provided in each abnormal configuration of the high lift devices likely to be used in flight following system failures (including all configurations covered by Airplane Flight Manual procedures)."
25.233(a), and 25.237(a), (b)(1) and (b)(2)	Change "0.2 V_{S0}" to "0.2 V_{SR0}."
SUBPART D	
25.735(f)(2)	Change the KE equation to read: "KE = $0.0443(WV^2/N)$" Change the V definition to read: "V = $V_{REF}/1.3$" and "V_{REF} = Airplane steady landing approach speed, in knots, at the maximum design landing weight and in the landing configuration at sea level; and"

25.735(g)	Change to read: "The minimum speed rating of each main wheel-brake assembly (that is, the initial speed used in the dynamometer tests) may not be more than the V used in the determination of kinetic energy in accordance with paragraph (f) of this section, assuming..."
25.773(b)(1)(i)	Change "1.6 V_{S1}" to "1.5 V_{SR1}."
SUBPART E	
25.1001(c)(1) and (c)(3)	Change 1.4 V_{S1} to 1.3 V_{SR1}.
SUBPART F	
25.1323(c)(1)	Change "1.3 V_{S1}" to "1.23 V_{SR1}."
25.1323(c)(2)	Change "1.3V_{S0}" to "1.23V_{SR0}."
25.1325(e)	Change "1.3 V_{S0}" to "1.23 V_{SR0}."
	Change "1.8 V_{S1}" to "1.7 V_{SR1}."

Explanation of how design features or alternative standards provide an equivalent level of safety to the level of safety intended by the regulation

The stall identification system allows Bombardier to use the 1-g stall speed criteria and therefore use reduced reference speeds for determining the minimum operating speeds. The 1-g stall speed combined with the reduced reference speeds possesses an equivalent level of safety to an airplane which uses the Vmin stall speeds in combination with the FAR 25 reference speeds.

FAA approval and documentation of the ELOS

The FAA has approved the aforementioned Equivalent Level of Safety Finding addressed in issue paper F-1. This memorandum provides standardized documentation of the ELOS that is non-proprietary and can be made available to the public. The Transport Airplane Directorate has assigned a unique ELOS Memorandum number to facilitate archiving and retrieval of this ELOS. This number should be listed in the Type Certificate Data Sheet in the Certification Basis section as a statement for a TC or ATC project or on page 3 of the STC for an STC project. An example of an appropriate statement is provided below.

Equivalent Safety Findings have been made for the following regulation(s):
Several FAR's for the use of 1-g Stall Speed (nonstructural items)
(documented in TAD ELOS Memo TC2500NY-T-F-1)

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Date

ELOS Originated by New York ACO:	Project Engineer: Bruce Valentine	Routing Symbol ANE-172